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Evaluation of Model Microphysics Within Precipitation Bands of Extratropical Cyclones

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Introduction

- It is hypothesized microphysical predictions have greater uncertainties/errors when there are complex interactions that result from mixed-phased processes like riming.
- Use Global Precipitation Measurement (GPM) Mission ground validation studies in Ontario, Canada to verify and improve parameterizations.

Motivating Questions

- How well do the various Weather Research and Forecasting (WRF) microphysical schemes predict snowband intensity and microphysics?
- What is the benefit of using a more sophisticated double moment ice/snow scheme as well as more advanced riming schemes?

Field Case Study – 18 February 2012

- Figure 1 shows the 9, 3, and 1-km WRF domains, and the case study location (red dot and inset).
- On 18 February 2012 there was a weak cyclone near Lake Huron and a weak warm front approaching from the southwest .
- Surface radar estimate and WRF underestimated precipitaiton during this event (Fig. 2).

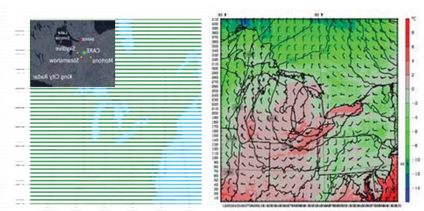

Figure 1. *(left) WRF model domains and the GCPEX field location site (red dot). (right) 11-h WRF forecast (at 1100 UTC 18 February 2012) showing SLP (every 2hPa), surface temperature (shaded) and surface winds (full barb = 10 kts).*

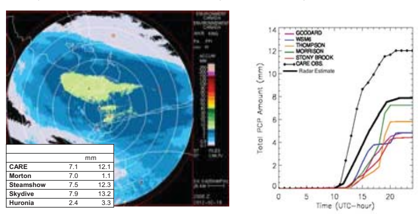

Figure 2. *(left – Courtesy Env. Canada) Storm total ground-radar estimate of precipitation using $Z = 178R^{1.677}$ and the gauge totals. (right) WRF members vs the observed and radar estimate at the CARE site (location on Fig. 1).*

Observed Versus WRF Radar Analysis

- WRF initial and boundary conditions from the 13-km RUC at 0000 UTC 18 February. Physics include: YSU PBL, GD CP scheme on 9-km only, and RRTM for LW, Dudhia scheme for SW Radiation.
- At 1100 UTC 18 February there was a warm frontal snowband observed near the field study site.
- Most of the 1-km WRF microphysical members realistically simulated this snowband, except the Thompson run was too weak.

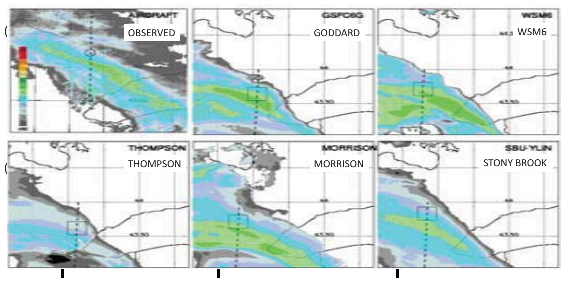

Figure 3. *Observed radar (0.5 deg) vs 1-km WRF (surface) reflectivity (shaded) at 1100 UTC 18 Feb 2012. North-south cross section locations (dashed) are band relative in order to compare radar and model.*

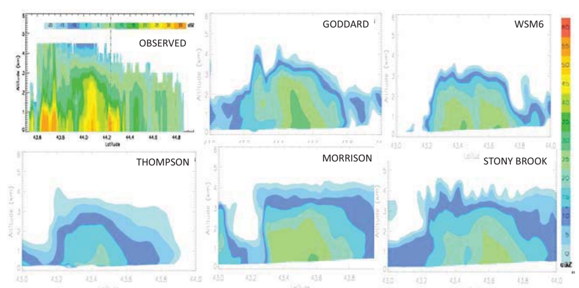

Figure 4. *Observed versus 1-km WRF-simulated radar reflectivity at 1100 UTC 18 Feb 2012 for the cross section locations shown in Fig. 2.*

- The observed snowband was associated with an enhanced area of reflectivity (25-35 dBZ) extending up to 3 km.
- The Goddard scheme most realistically predicted the structure of the narrow snowband (Thompson too weak).
- There were convective cells aloft that were predicted in the Goddard and Stony Brook (SBU-YLin) schemes.
- There was little cloud water (LWC) observed and simulated on the north (cold) side of the preciptiation band (Fig 5).

Microphysical Comparisons

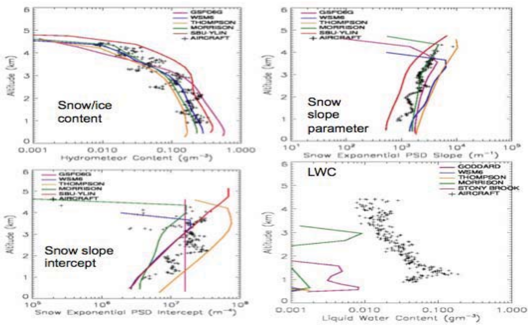

Figure 5. *Mean 1-km WRF profiles of ice water content, snow exponential PSD slope parameter and intercept, and liquid water content for the boxes in Fig. 3 in comparison to aircraft spiral.*

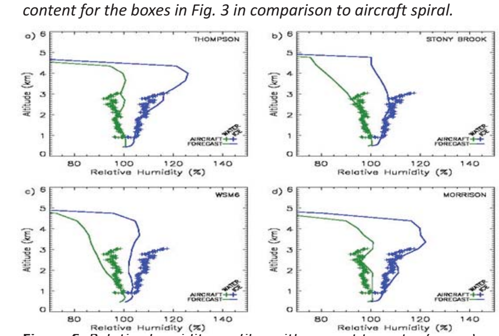

Figure 6. *Relative humidity profiles with respect to water (green) and ice (blue) for the aircraft (+) and WRF (solid line) at 1100 UTC 18 Feb 2012.*

- WRF microphysical predictions were averaged within the boxes in Fig. 3, which is location of aircraft spiral.
- At 1100 UTC (north side of band), all WRF schemes realistically predicted the ice water content profiles. The Thompson tended to underpredict, and Goddard/SBU-YLIN overpredict.
- Morrison best predicted the snow distribution (slope), but had difficulty with the intercept. The temperature dependent slope intercept schemes (SBU and WSM) had a closer intercept to the aircraft observations.
- The WSM6 and SBU relative humidities tend to be too low (likely because of the saturation adjustment scheme used), while the Thompson and Morrison are slightly too moist.

- By 1230 UTC (center of snow band), the Goddard and SBU most realistically predicted the narrow structure of the band. Thompson was too weak.
- There was much more cloud water observed, which was underpredicted by all schemes.
- The slope intercept and distribution results are similar to earlier times.

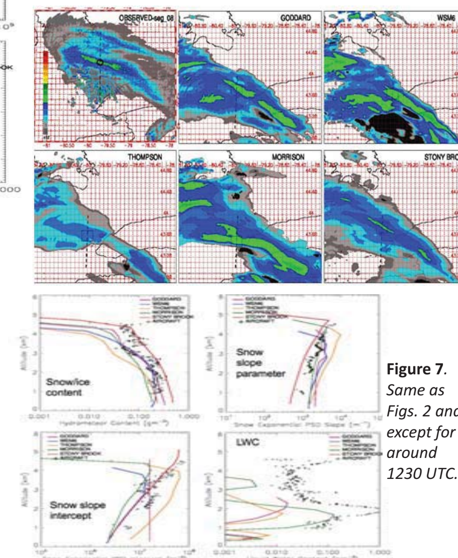

Figure 7. *Same as Figs. 2 and 6 except for around 1230 UTC.*

Summary and Conclusions

- The WRF realistically simulated the warm frontal snowband at relatively short lead times (10-14 h).
- The snowband structire is sensitive to the microphysical parameterization used in WRF.
- The Goddard and SBU-YLin most realistically predicted the band structure, but overpredicted snow content.
- The double moment Morrison scheme best produced the slope of the snow distribution, but it underpredicted the intercept.
- All schemes and the radar derived (which used dry snow Z-R) underpredicted the surface precipitation amount, likely because there was more cloud water than expected. The Morrison had the most cloud water and the best precipitation prediction of all schemes.

Acknowledgements

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